

# **Formative Measurement Models in Covariance Structure Analysis: Specification and Identification**

Dirk Temme\*  
Lutz Hildebrandt\*



\* Institute of Marketing, Humboldt-Universität zu Berlin, Germany

This research was supported by the Deutsche  
Forschungsgemeinschaft through the SFB 649 "Economic Risk".

<http://sfb649.wiwi.hu-berlin.de>  
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin  
Spandauer Straße 1, D-10178 Berlin



# Formative measurement models in covariance structure analysis: Specification and identification<sup>1</sup>

**Dirk Temme, Lutz Hildebrandt**

Institute of Marketing, Humboldt University Berlin  
Spandauer Straße 1, 10099 Berlin  
{temme, hildebr}@wiwi.hu-berlin.de

## **Abstract**

Many researchers seem to be unsure about how to specify formative measurement models in software programs like LISREL or AMOS and to establish identification of the corresponding structural equation model. In order to make identification easier, a new, mainly graphically-oriented approach is presented for a specific class of recursive models with formative indicators. Using this procedure it is shown that some models have erroneously been considered underidentified. Furthermore, it is shown that specifying formative indicators as exogenous variables rises serious conceptual and substantial issues in the case that the formative construct is truly endogenous (i. e. influenced by more remote causes). An empirical study on the effects and causes of brand competence illustrates this point.

**Keywords:** Formative indicators; Latent variables; Covariance structure analysis; Identification

**JEL-Codes:** C31, C51, C52, M31

---

<sup>1</sup> Financial support by the Deutsche Forschungsgemeinschaft (DFG) through the SFB 649 “Economic Risk” is gratefully acknowledged.

## 1. Introduction

At least since the seminal papers by Diamantopoulos and Winklhofer (2001), Rossiter (2002), and Jarvis, MacKenzie, and Podsakoff (2003) researchers in marketing are sensitized for thinking thoroughly about the conceptualization and operationalization of their theoretical constructs as either reflective or formative (or possibly some combination of both). Simultaneously, the broadened perspective on the specification of measurement models has begun to alter the researchers' decisions on the statistical method to be used for the estimation of structural equation models with latent variables (SEM). Whereas the "Churchill paradigm" (Churchill, 1979) with its focus on reflective constructs has prompted the researchers to apply – almost exclusively – covariance structure analysis (CSA), researchers now more and more turn to the partial least squares approach (PLS; Wold, 1966) if formative constructs are involved. The most important driver of this development is arguably the fact that many researchers are unsure about how to specify formative measurement models in software programs like LISREL or AMOS and to establish identification of the corresponding SEM (Jarvis, MacKenzie, & Podsakoff, 2003). This uncertainty is even echoed in claims that CSA is not able to handle formative indicators (e.g., Dellande, Gilly, & Graham, 2004). Although such claims can be easily refuted, they contribute to a widespread impression that accommodating formative constructs in the CSA framework is a rather difficult task which should better be avoided. In contrast, with PLS the user does not have to bother with the identification of such models and estimation is fairly easy with the new generation of software (e.g., PLSGraph, SmartPLS).

Given the apparent advantage that PLS has for SEM with formative constructs, one might ask why to deal with the specification of such models in CSA anyway. There are several reasons which can be put forth: First, if the manifest indicators of (reflective) latent variables are contaminated by measurement error, unbiasedness of the parameter estimates in PLS rests on the "consistency at large" condition with respect to the number of indicators (Wold, 1980). Since such a requirement is almost never fulfilled in empirical studies, PLS parameter estimates are typically biased to a certain degree (Dijkstra, 1984; McDonald, 1996). Second, beyond the fundamental linear predictor specification PLS does not impose any restrictions on the data. Therefore, no overall test of model fit is available so far. Third, in contrast to CSA the PLS approach is restricted to recursive models, i. e. no feedback loops or reciprocal relationships can be estimated.

Consequently, there are some important arguments not to abandon CSA in the case of formative constructs. However, in order to make CSA a reasonable alternative to the PLS approach from the researcher's point of view, easy-to-apply rules to assess the identification status of her/his models must be established. Unfortunately, identification of formative measurement models is still an underresearched issue. With the exception of some unpublished work by Bollen and Davis (1994) all identification rules discussed in the relevant literature (Bollen & Lennox, 1991; MacCallum & Browne, 1993; Edwards & Bagozzi, 2001; Jarvis, MacKenzie, & Podsakoff, 2003) are restricted to the case of a single formative construct and even here the stated rules can be misleading. Our paper contributes to the research on formative constructs by suggesting a graphically-oriented approach for identifying a specific class of models. We also show that this approach allows to identify models which have formerly been regarded as underidentified.

Whereas the identification of formative measurement models in CSA has at least been identified as an important problem, another issue is almost completely neglected in the literature. If model specification for formative constructs embedded in extensive nomological nets is covered at all, most articles exclusively focus on "exogenous" formative constructs (i.e. constructs without any further causes except their indicators/components). Even if "endogenous" formative constructs (i. e., constructs influenced by more remote causes than their indicators) are involved, the corresponding indicators are still considered exogenous (e.g., MacCallum & Browne, 1993). This paper aims to show that such a specification gives rise to serious conceptual and substantial issues. As a consequence, we propose to specify both direct and indirect effects (via the formative indicators) of the remote causes on the formative construct.

In the following, we first deal with the identification of SEM including formative constructs. Secondly, we discuss some specification problems for truly endogenous formative constructs. The consequences of misspecifying the relationships in this case are finally illustrated by an empirical study on the causes and effects of brand competence. We finish with some concluding remarks.

## **2. Identification**

For our purpose, a formative construct  $\eta_j$  ( $j = 1, \dots, m$ ) is defined as follows (for a discussion of different perspectives see Bollen & Lennox, 1991; Diamantopoulos & Winklhofer, 2001):

$$\eta_j = \gamma_{j1}x_1 + \gamma_{j2}x_2 + \dots + \gamma_{jq}x_q + \zeta_j,$$

where  $x_s$  ( $s = 1, \dots, q$ ) are the formative indicators. At least conceptually, the stochastic disturbance  $\zeta_j$  represents those facets of the construct which have not been observed (for a more thorough treatment concerning the interpretation of  $\zeta_j$  see Diamantopoulos (2006)). For  $\zeta_j$  the typical assumptions apply: The indicators are uncorrelated with  $\zeta_j$  and  $E(\zeta_j) = 0$ . Formative constructs will also be referred to as composite latent variables (CLV; Jarvis, MacKenzie, & Podsakoff, 2003). As a further extension, the indicators in the equation above can be substituted by multiple reflective constructs representing the various components of the formative construct (Edwards, 2001).<sup>2</sup>

Just as with reflective constructs, identification of formative measurement models in CSA is bound to two basic conditions. First, the number of free parameters  $t$  in the overall model must not exceed the number of non-redundant elements in the empirical variance-covariance matrix (t-rule; Bollen, 1989). Second, each latent variable needs to be scaled. In the literature different options (e.g., fixing the path of the CLV to a reflective indicator or the variance of the CLV to 1) are discussed (Bollen & Davis, 1994; MacCallum & Browne, 1993).

Beyond the necessary but insufficient requirements presented above, further conditions discussed in the literature are often not very helpful for identifying models of practical relevance or might even be misleading. For instance, Jarvis, MacKenzie, & Podsakoff (2003) note that for the error terms of formative constructs to be identified it is necessary that they “emit paths to (a) at least two **unrelated** [emphasis by the authors] latent constructs with reflective indicators [...], (b) at least two theoretically appropriate reflective indicators [...], or (c) one reflective indicator and one latent construct with reflective indicators [...]” (p. 213). Based on this rule, MacKenzie, Podsakoff, & Jarvis (2005) erroneously conclude for the model by Law and Wong (1999) depicted in Fig. 1 that “[...] the error term for the job perception construct was not identified when job perception was specified as having formative indicators. This is because the job perception construct did not have two paths emanating from it that led to independent constructs. It had two paths leading from it, but the two constructs were causally related.” (p. 716). Although it is true that at least two paths leading to other variables are necessary for a CLV to be identified, the former need not be unrelated in a larger model.

---

<sup>2</sup> For ease of exposition we only consider formative observed indicators here. However, the identification issues dealt with in this section also apply to the case that reflective constructs make the CLV appear.

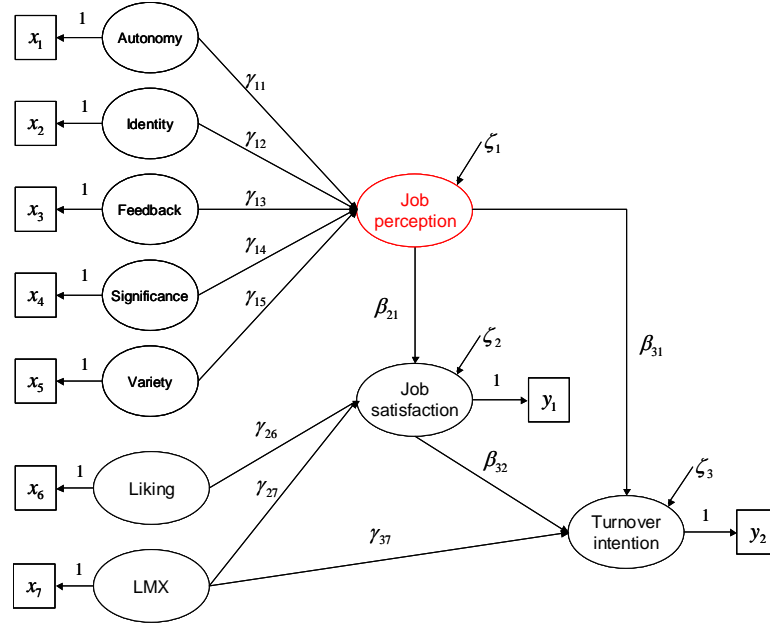


Fig. 1. Model on job perception by Law & Wong (1999)

In order to show that the model by Law and Wong (1999) is indeed identified, we introduce a new, mainly graphically-oriented approach which consists of the following three steps (for a related but completely algebraic procedure see Cantaluppi (2002)):

- I. Transform the original model into a model without CLVs.
- II. Check identification of the transformed model.
- III. Check that the parameters of the original model can be unambiguously derived from the parameters of the transformed model.

Our procedure is meant to be applied if structural relationships have been defined between those variables which are directly dependent from the CLV. However, it is assumed that the model is recursive, i. e. there are no feedback loops or correlated disturbances.

We now illustrate the approach for the model by Law and Wong (1999). Starting from the graph in Fig. 1, substep (1) in transforming this model consists in choosing a CLV (in the case at hand only one is present: job perception). In substep (2) all variables directly influenced by this CLV (i. e. job satisfaction and turnover intention) are connected by double-headed arrows. All arrows emanating from the CLV are then eliminated in substep (3). In substep (4) the CLV is substituted by its formative indicators. Finally, for each of these indicators an arrow is drawn to those variables which were originally influenced by the CLV. The output of substep (5) in our example leads to the graph in Fig. 2. In the case of more than one CLV, steps (1) to (5) are repeated as long as there are CLVs in the partially transformed model.

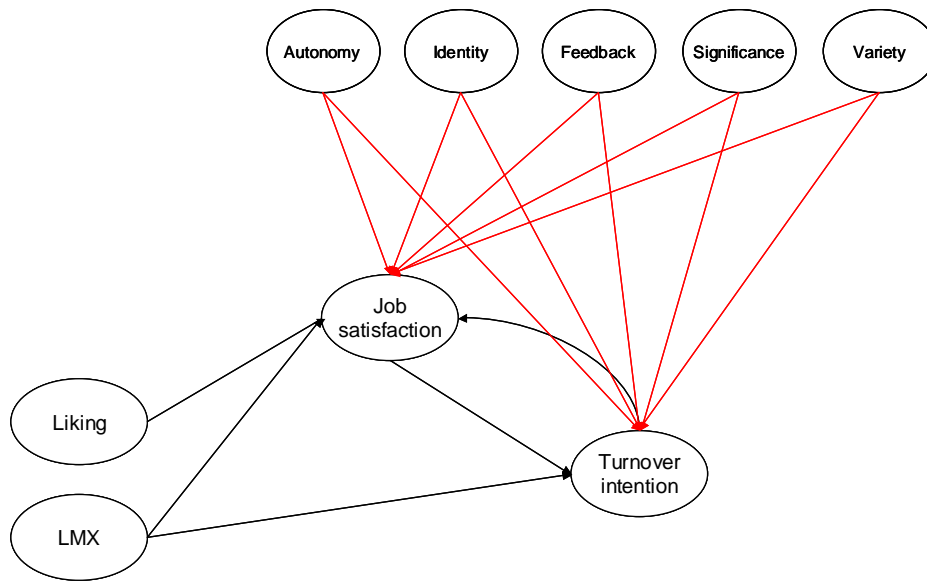


Fig. 2. Transformed model resulting from step II

Step II now requires to show that the transformed model is identified. Since the graph exhibits a so-called bow-pattern (Brito & Pearl, 2002), i. e. the model is not identified per se, we rely on Rigdon's (1995) identification rules for nonrecursive blocks of two endogenous variables. Because our transformed model resembles his case 8, the model has to be re-classified: The formative indicators influence both job satisfaction and turnover intention and therefore do not contribute to model identification. Eliminating the indicators finally leads to the graph depicted in Fig. 3. Because this model corresponds to Rigdon's case 3, identification of the transformed model has been established. Since it can be shown that the transformed model's parameters allow for an unambiguous derivation of the original parameters (not shown here because of space limitations), also the original model is identified.

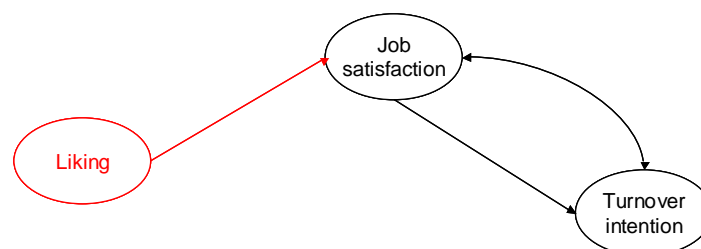


Fig. 3. Re-classified graph

### 3. Specification of quasi-exogenous and endogenous CLV

In the literature, formative indicators/components<sup>3</sup> are almost ever considered as exogenous independent from the causal status of the formative construct. However, although formative constructs are by definition endogenous, two cases need to be distinguished here: First, the CLV is only determined by its indicators (and some disturbance term which captures the neglected facets of the construct). We will use the notion quasi-exogenous to refer to such kind of CLV. In this case, the covariances between the formative indicators and the other exogenous variables (i. e. other constructs' formative indicators or latent variables) are typically estimated freely (MacCallum & Browne, 1993). Second, above being formed by its indicators, the formative construct is influenced by other, more remote causes (e.g., reflective latent constructs or quasi-exogenous CLV). Such a variable will be called an endogenous CLV from now on. In this case, the habitual supposition of exogenous formative indicators raises serious issues both conceptually and substantially.

From a conceptual point of view, if some remote causes are assumed to influence the CLV but its indicators are specified as exogenous variables, it remains unclear how a causal process can actually take place. If we take the view that formative indicators produce the CLV serious, such an effect should mainly operate via all or some of the formative indicators, thus turning the latter into endogenous variables. An example might further clarify this issue: Let us assume that we are interested in how a salary increase impacts on an employee's job satisfaction. Would'nt we expect that job satisfaction raises mainly as a consequence of pay satisfaction (one of the construct's components) being improved?

From a substantial perspective, specifying only the "direct" effect of a remote cause on a CLV will almost inevitably lead to a biased estimate. The two models A and B in Fig. 4 illustrate this issue. In both models the latent exogenous variable  $\xi_1$  exerts a direct effect ( $\gamma_{31}$ ) on the endogenous CLV  $\eta_3^F$ . For model A, effects of  $\xi_1$  on the formative indicators  $y_1 (\equiv \eta_1)$  and  $y_2 (\equiv \eta_2)$  are specified in addition to the direct effect ( $\gamma_{11}$  and  $\gamma_{21}$ ). Altogether, this leads to a total effect of  $\gamma_{31} + \gamma_{11}\beta_{31} + \gamma_{21}\beta_{32}$  for  $\xi_1$ . In contrast, model B reflects the common approach of specifying covariances between  $\xi_1$  and the "exogenous" formative indicators. Here, the influence of  $\xi_1$  is restricted to the direct effect  $\gamma_{31}$ . Dependent from the signs of the coefficients  $\gamma_{11}$ ,  $\gamma_{21}$ ,  $\beta_{31}$ , and  $\beta_{32}$ , the true impact of  $\xi_1$  is either under- or overestimated.<sup>4</sup>

---

<sup>3</sup> Again, in the following we will only use the term indicator but the reader should keep in mind that our exposition also applies to reflective constructs specified as components of a formative construct.

<sup>4</sup>It should be noted that the two alternative specifications are empirically undistinguishable (i. e. they show the same overall fit).



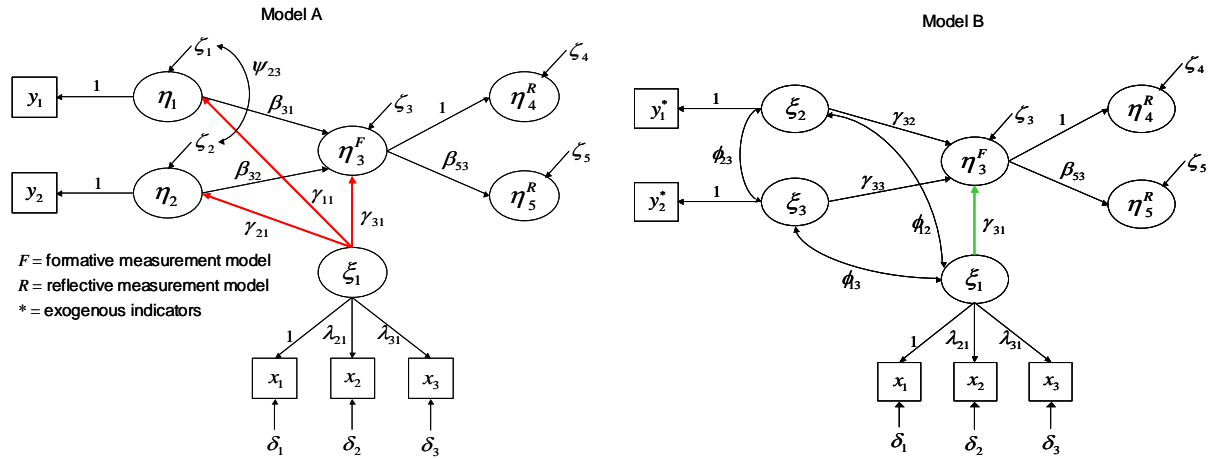


Fig. 4. Specifying endogenous CLV with either endogenous or exogenous indicators

#### 4. Empirical study on the causes and effects of brand competence

In order to show how specifying exogenous indicators in the case of truly endogenous formative constructs can produce misleading results, we shortly present an empirical study on the causes and effects of brand competence. Results are based on survey data for 261 consumers collected by GfK Market Research. Respondents were requested to evaluate various brands in the fixatives and denture cleansers market. Specifically, we were interested in how perceived advertising intensity for the leading brand in the two product categories as well as the perceived extent to which dentists recommend this brand influence its perceived competence. A brand can be considered competent if it has “the ability to solve a consumer’s problem and to meet his or her need” (Lau & Lee, 2000). In addition, the effect of brand competence on brand strength has been analyzed (see Fig. 5 which represents model 1).

Brand competence in our study is supposed to be formed by four indicators (e. g., “stands for hygiene and cleanliness”, “stands for attractiveness and beauty”). The exogenous variables advertising (“really advertises a lot”) and recommendations (“is recommended by dentists”) are measured by a single indicator. The perceived attractiveness of the brand (i. e. brand strength) is reflected by eight indicators which capture the affective, cognitive, and intentional responses toward the brand. In order to identify the model, overall brand competence is additionally measured by two reflective indicators.

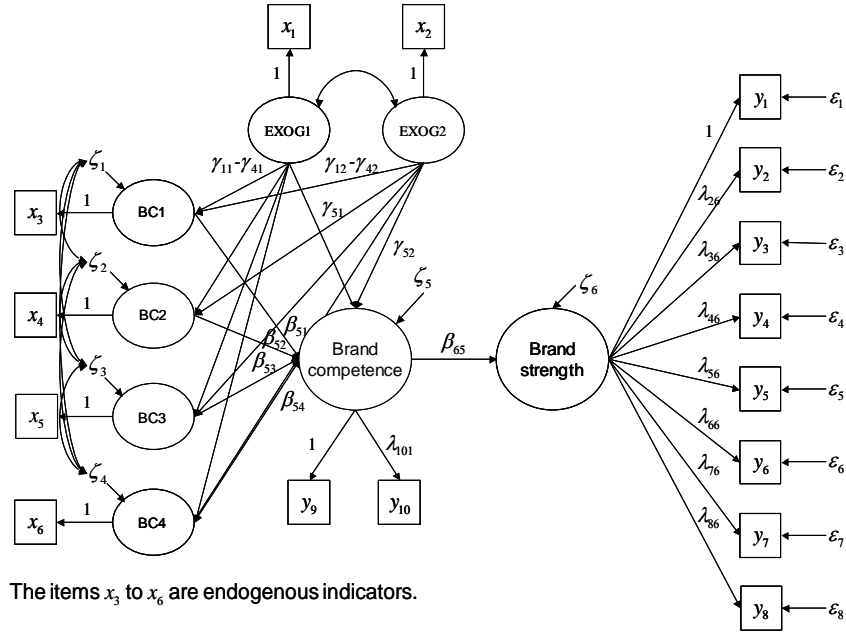


Fig. 5. Structural equation model of brand competence – Causes and effects

Maximum likelihood estimation of the model in Fig. 5 using LISREL 8.72 leads to an excellent model fit ( $\chi^2 = 158.05$ ,  $df = 87$ ,  $RMSEA = 0.052$ ,  $CFI = 0.987$ ). Selected parameter estimates can be found in Table 1. Advertising has both a significant and positive direct effect ( $\gamma_{51}$ ) on brand competence and on one of the components ( $\gamma_{21}$ ). Overall, a significant positive total effect emerges (Table 2). In contrast, recommendations by dentists only exert an indirect effect on brand competence by increasing two of its indicators (at the 5 % level). Although the indirect influence is significantly positive, in total recommendations do not seem to have an impact on brand competence.

In contrast to the former model, in model 2 the formative indicators have been specified as exogenous variables. Since only direct effects of the two exogenous variables are estimated (see Table 1) and the indirect effects have been shown to be positive, the total effects are therefore underestimated (see Table 2). A closer look at the coefficients for model 1 reveals that the insignificant total effect for recommendations can be explained by the fact that the direct effect, albeit not significant, is negative. Therefore, we tested an alternative specification where this direct effect has been fixed to zero (together with the parameter  $\gamma_{41}$  which was likewise almost nil). Since model fit showed almost no deterioration ( $\chi^2 = 158.66$ ,  $df = 89$ ), it seems justified to conclude that dentists recommending a brand indeed exert a positive influence on brand competence.

Table 1  
Direct effects of the exogenous variables

Explanatory variable	Parameter	Model 1	Model 2	Model 3
Advertising (EXOG1)	$\gamma_{11}$	0.077 <i>0.102</i>	—	0.076 <i>0.101</i>
	$\gamma_{21}$	0.133*** <i>0.160</i>	—	0.131*** <i>0.158</i>
	$\gamma_{31}$	0.081 <i>0.099</i>	—	0.080 <i>0.098</i>
	$\gamma_{41}$	0.005 <i>0.005</i>	—	—
	$\gamma_{51}$	0.155*** <i>0.261</i>	0.155*** <i>0.261</i>	0.148*** <i>0.250</i>
Recommendation (EXOG2)	$\gamma_{12}$	0.097* <i>0.120</i>	—	0.097* <i>0.121</i>
	$\gamma_{22}$	0.194*** <i>0.220</i>	—	0.194*** <i>0.220</i>
	$\gamma_{32}$	0.088 <i>0.102</i>	—	0.089 <i>0.102</i>
	$\gamma_{42}$	0.160** <i>0.161</i>	—	0.162*** <i>0.163</i>
	$\gamma_{52}$	−0.030 <i>−0.048</i>	−0.030 <i>−0.048</i>	—

\*\*\*  $p \leq 0.01$ , \*\*  $p \leq 0.05$ , \*  $p \leq 0.10$ ; standardized parameter estimates in italic

Table 2  
Total and indirect effects

	Model 1	Model 2	Model 3
<b>Indirect effects</b>			
Advertising → Brand competence	0.056** <i>0.094</i>	—	0.054** <i>0.092</i>
Recommendation → Brand competence	0.073** <i>0.116</i>	—	0.072** <i>0.114</i>
<b>Total effects</b>			
Advertising →			
Brand competence	0.211*** <i>0.356</i>	0.155*** <i>0.261</i>	0.203*** <i>0.341</i>
Brand strength	0.193*** <i>0.222</i>	0.142*** <i>0.163</i>	0.186*** <i>0.214</i>
Recommendation →			
Brand competence	0.043 <i>0.068</i>	−0.030 <i>−0.048</i>	0.072** <i>0.114</i>
Brand strength	0.039 <i>0.043</i>	−0.028 <i>−0.030</i>	0.066** <i>0.074</i>

\*\*\*  $p \leq 0.01$ , \*\*  $p \leq 0.05$ , \*  $p \leq 0.10$ ; standardized parameter estimates in italic

## **5. Conclusion**

In this paper we have shown that established identification rules for models including formative constructs in part can be misleading. To remedy this issue a new procedure has been proposed which allows the user to establish model identification mainly by graphical criteria. It has been shown that even two related variables influenced by a formative construct can suffice to identify that construct if it is embedded in a larger network. Since so far our approach is restricted to recursive models, further research should consider the case of nonrecursive models. Furthermore, we have identified the shortcomings of the almost standard practice of specifying exogenous indicators in the case of truly endogenous formative constructs: For all practical purposes, the influence of the remote causes will be under- or overestimated. In our empirical study, this might have lead managers to undervalue the positive effect recommendations by dentists have on the perceived competence of a brand for fixatives and denture cleansers.

## References

- Bollen, K. A. (1989). *Structural Equations with Latent Variables*. New York: Wiley.
- Bollen K. A., & Davis W. R. (1994). Causal indicator models: identification, estimation, and testing, *Working Paper*, University of North Carolina at Chapel Hill.
- Bollen, K., & Lennox, R. (1991). Conventional wisdom on measurement: a structural equation perspective. *Psychological Bulletin*, 110(2), 305–314.
- Brito, C., & Pearl, J. (2002). A new identification condition for recursive models with correlated errors. *Structural Equation Modeling*, 9(4), 459–474.
- Cantaluppi, G. (2002). The problem of parameter identification of structural equation models with both formative and reflexive relationships: some theoretical results, *Working Paper Serie E.P. N. 108*, Università Cattolica del Sacro Cuore, Milano.
- Churchill, G. A., Jr. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research*, 16, 64–73.
- Dellande, S., Gilly, M. C., & Graham, J. L. (2004). Gaining compliance and losing weight: the role of the service provider in health care services. *Journal of Marketing*, 68, 78–91.
- Diamantopoulos, A. (2006). The error term in formative measurement models: interpretation and modeling implications. *Journal of Modelling in Management*, 1(1), 7–17.
- Diamantopoulos, A. & Winklhofer, H. M. (2001). Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research*, 38, 269–277.
- Edwards, J. R. (2001). Multidimensional constructs in organisational behavior research: An integrative analytical framework. *Organisational Research Methods*, 4(2), pp. 144–192.
- Edwards, J. R., & Bagozzi, R. P. (2000). On the nature and direction of relationships between constructs and measures. *Psychological Methods*, 5(2), 155–174.
- Dijkstra, T. (1983). Some comments on maximum likelihood and partial least squares methods. *Journal of Econometrics*, 22(1/2), 67–90.
- Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research*, 30, 199–218.
- Lau, G. T., & Lee, S. H. (1999). Consumers' trust in a brand and the link to brand loyalty. *Journal of Market Focused Management*, 4, 341–370.
- Law, K. S., & Wong, C.-S. (1999). Multidimensional constructs in structural equation analysis: an illustration using the job perception and job satisfaction constructs. *Journal of Management*, 25(2), 143–160.
- MacCallum, R. C., & Browne, M. W. (1993). The use of causal indicators in covariance structure models: Some practical issues. *Psychological Bulletin*, 114(3), 533–541.
- McDonald, R. P. (1996). Path analysis with composite variables. *Multivariate Behavioral Research*, 31(2), 239–270.
- Rigdon, E. E. (1995). A necessary and sufficient identification rule for structural models estimated in practice. *Multivariate Behavioral Research*, 30(3), 359–383.
- Rossiter, J. R. (2002). The C-OAR-SE procedure for scale development in marketing. *International Journal of Research in Marketing*, 19(4), pp. 305–335.

- Wold, H. (1966). Estimation of principal components and related models by iterative least squares. In P. R. Krishnaiah (Ed.), *Multivariate analysis*. New York.
- Wold, H. (1980). Model construction and evaluation when theoretical knowledge is scarce. In J. Kmenta & J. B. Ramsey (Eds.), *Model evaluation in econometrics*. New York: Academic Press.

## SFB 649 Discussion Paper Series 2006

For a complete list of Discussion Papers published by the SFB 649, please visit <http://sfb649.wiwi.hu-berlin.de>.

- 001 "Calibration Risk for Exotic Options" by Kai Detlefsen and Wolfgang K. Härdle, January 2006.
- 002 "Calibration Design of Implied Volatility Surfaces" by Kai Detlefsen and Wolfgang K. Härdle, January 2006.
- 003 "On the Appropriateness of Inappropriate VaR Models" by Wolfgang Härdle, Zdeněk Hlávka and Gerhard Stahl, January 2006.
- 004 "Regional Labor Markets, Network Externalities and Migration: The Case of German Reunification" by Harald Uhlig, January/February 2006.
- 005 "British Interest Rate Convergence between the US and Europe: A Recursive Cointegration Analysis" by Enzo Weber, January 2006.
- 006 "A Combined Approach for Segment-Specific Analysis of Market Basket Data" by Yasemin Boztuğ and Thomas Reutterer, January 2006.
- 007 "Robust utility maximization in a stochastic factor model" by Daniel Hernández-Hernández and Alexander Schied, January 2006.
- 008 "Economic Growth of Agglomerations and Geographic Concentration of Industries - Evidence for Germany" by Kurt Geppert, Martin Gornig and Axel Werwatz, January 2006.
- 009 "Institutions, Bargaining Power and Labor Shares" by Benjamin Bental and Dominique Demougin, January 2006.
- 010 "Common Functional Principal Components" by Michal Benko, Wolfgang Härdle and Alois Kneip, January 2006.
- 011 "VAR Modeling for Dynamic Semiparametric Factors of Volatility Strings" by Ralf Brüggemann, Wolfgang Härdle, Julius Mungo and Carsten Trenkler, February 2006.
- 012 "Bootstrapping Systems Cointegration Tests with a Prior Adjustment for Deterministic Terms" by Carsten Trenkler, February 2006.
- 013 "Penalties and Optimality in Financial Contracts: Taking Stock" by Michel A. Robe, Eva-Maria Steiger and Pierre-Armand Michel, February 2006.
- 014 "Core Labour Standards and FDI: Friends or Foes? The Case of Child Labour" by Sebastian Braun, February 2006.
- 015 "Graphical Data Representation in Bankruptcy Analysis" by Wolfgang Härdle, Rouslan Moro and Dorothea Schäfer, February 2006.
- 016 "Fiscal Policy Effects in the European Union" by Andreas Thams, February 2006.
- 017 "Estimation with the Nested Logit Model: Specifications and Software Particularities" by Nadja Silberhorn, Yasemin Boztuğ and Lutz Hildebrandt, March 2006.
- 018 "The Bologna Process: How student mobility affects multi-cultural skills and educational quality" by Lydia Mechtenberg and Roland Strausz, March 2006.
- 019 "Cheap Talk in the Classroom" by Lydia Mechtenberg, March 2006.
- 020 "Time Dependent Relative Risk Aversion" by Enzo Giacomini, Michael Handel and Wolfgang Härdle, March 2006.
- 021 "Finite Sample Properties of Impulse Response Intervals in SVECMs with Long-Run Identifying Restrictions" by Ralf Brüggemann, March 2006.
- 022 "Barrier Option Hedging under Constraints: A Viscosity Approach" by Imen Bentahar and Bruno Bouchard, March 2006.

**SFB 649, Spandauer Straße 1, D-10178 Berlin**  
**<http://sfb649.wiwi.hu-berlin.de>**

This research was supported by the Deutsche  
Forschungsgemeinschaft through the SFB 649 "Economic Risk".



- 023 "How Far Are We From The Slippery Slope? The Laffer Curve Revisited" by Mathias Trabandt and Harald Uhlig, April 2006.
- 024 "e-Learning Statistics – A Selective Review" by Wolfgang Härdle, Sigbert Klinke and Uwe Ziegenhagen, April 2006.
- 025 "Macroeconomic Regime Switches and Speculative Attacks" by Bartosz Maćkowiak, April 2006.
- 026 "External Shocks, U.S. Monetary Policy and Macroeconomic Fluctuations in Emerging Markets" by Bartosz Maćkowiak, April 2006.
- 027 "Institutional Competition, Political Process and Holdup" by Bruno Deffains and Dominique Demougin, April 2006.
- 028 "Technological Choice under Organizational Diseconomies of Scale" by Dominique Demougin and Anja Schöttner, April 2006.
- 029 "Tail Conditional Expectation for vector-valued Risks" by Imen Bentahar, April 2006.
- 030 "Approximate Solutions to Dynamic Models – Linear Methods" by Harald Uhlig, April 2006.
- 031 "Exploratory Graphics of a Financial Dataset" by Antony Unwin, Martin Theus and Wolfgang Härdle, April 2006.
- 032 "When did the 2001 recession *really* start?" by Jörg Polzehl, Vladimir Spokoiny and Cătălin Stărică, April 2006.
- 033 "Varying coefficient GARCH versus local constant volatility modeling. Comparison of the predictive power" by Jörg Polzehl and Vladimir Spokoiny, April 2006.
- 034 "Spectral calibration of exponential Lévy Models [1]" by Denis Belomestny and Markus Reiß, April 2006.
- 035 "Spectral calibration of exponential Lévy Models [2]" by Denis Belomestny and Markus Reiß, April 2006.
- 036 "Spatial aggregation of local likelihood estimates with applications to classification" by Denis Belomestny and Vladimir Spokoiny, April 2006.
- 037 "A jump-diffusion Libor model and its robust calibration" by Denis Belomestny and John Schoenmakers, April 2006.
- 038 "Adaptive Simulation Algorithms for Pricing American and Bermudan Options by Local Analysis of Financial Market" by Denis Belomestny and Grigori N. Milstein, April 2006.
- 039 "Macroeconomic Integration in Asia Pacific: Common Stochastic Trends and Business Cycle Coherence" by Enzo Weber, May 2006.
- 040 "In Search of Non-Gaussian Components of a High-Dimensional Distribution" by Gilles Blanchard, Motoaki Kawanabe, Masashi Sugiyama, Vladimir Spokoiny and Klaus-Robert Müller, May 2006.
- 041 "Forward and reverse representations for Markov chains" by Grigori N. Milstein, John G. M. Schoenmakers and Vladimir Spokoiny, May 2006.
- 042 "Discussion of 'The Source of Historical Economic Fluctuations: An Analysis using Long-Run Restrictions' by Neville Francis and Valerie A. Ramey" by Harald Uhlig, May 2006.
- 043 "An Iteration Procedure for Solving Integral Equations Related to Optimal Stopping Problems" by Denis Belomestny and Pavel V. Gapeev, May 2006.
- 044 "East Germany's Wage Gap: A non-parametric decomposition based on establishment characteristics" by Bernd Görzig, Martin Gornig and Axel Werwatz, May 2006.
- 045 "Firm Specific Wage Spread in Germany - Decomposition of regional differences in inter firm wage dispersion" by Bernd Görzig, Martin Gornig and Axel Werwatz, May 2006.

**SFB 649, Spandauer Straße 1, D-10178 Berlin**  
<http://sfb649.wiwi.hu-berlin.de>

This research was supported by the Deutsche  
Forschungsgemeinschaft through the SFB 649 "Economic Risk".

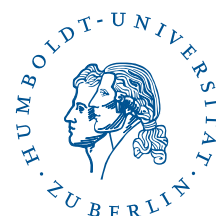




- 046 "Produktdiversifizierung: Haben die ostdeutschen Unternehmen den Anschluss an den Westen geschafft? – Eine vergleichende Analyse mit Mikrodaten der amtlichen Statistik" by Bernd Görzig, Martin Gornig and Axel Werwatz, May 2006.
- 047 "The Division of Ownership in New Ventures" by Dominique Demougin and Oliver Fabel, June 2006.
- 048 "The Anglo-German Industrial Productivity Paradox, 1895-1938: A Restatement and a Possible Resolution" by Albrecht Ritschl, May 2006.
- 049 "The Influence of Information Costs on the Integration of Financial Markets: Northern Europe, 1350-1560" by Oliver Volckart, May 2006.
- 050 "Robust Econometrics" by Pavel Čížek and Wolfgang Härdle, June 2006.
- 051 "Regression methods in pricing American and Bermudan options using consumption processes" by Denis Belomestny, Grigori N. Milstein and Vladimir Spokoiny, July 2006.
- 052 "Forecasting the Term Structure of Variance Swaps" by Kai Detlefsen and Wolfgang Härdle, July 2006.
- 053 "Governance: Who Controls Matters" by Bruno Deffains and Dominique Demougin, July 2006.
- 054 "On the Coexistence of Banks and Markets" by Hans Gersbach and Harald Uhlig, August 2006.
- 055 "Reassessing Intergenerational Mobility in Germany and the United States: The Impact of Differences in Lifecycle Earnings Patterns" by Thorsten Vogel, September 2006.
- 056 "The Euro and the Transatlantic Capital Market Leadership: A Recursive Cointegration Analysis" by Enzo Weber, September 2006.
- 057 "Discounted Optimal Stopping for Maxima in Diffusion Models with Finite Horizon" by Pavel V. Gapeev, September 2006.
- 058 "Perpetual Barrier Options in Jump-Diffusion Models" by Pavel V. Gapeev, September 2006.
- 059 "Discounted Optimal Stopping for Maxima of some Jump-Diffusion Processes" by Pavel V. Gapeev, September 2006.
- 060 "On Maximal Inequalities for some Jump Processes" by Pavel V. Gapeev, September 2006.
- 061 "A Control Approach to Robust Utility Maximization with Logarithmic Utility and Time-Consistent Penalties" by Daniel Hernández-Hernández and Alexander Schied, September 2006.
- 062 "On the Difficulty to Design Arabic E-learning System in Statistics" by Taleb Ahmad, Wolfgang Härdle and Julius Mungo, September 2006.
- 063 "Robust Optimization of Consumption with Random Endowment" by Wiebke Wittmüß, September 2006.
- 064 "Common and Uncommon Sources of Growth in Asia Pacific" by Enzo Weber, September 2006.
- 065 "Forecasting Euro-Area Variables with German Pre-EMU Data" by Ralf Brüggemann, Helmut Lütkepohl and Massimiliano Marcellino, September 2006.
- 066 "Pension Systems and the Allocation of Macroeconomic Risk" by Lans Bovenberg and Harald Uhlig, September 2006.
- 067 "Testing for the Cointegrating Rank of a VAR Process with Level Shift and Trend Break" by Carsten Trenkler, Pentti Saikkonen and Helmut Lütkepohl, September 2006.
- 068 "Integral Options in Models with Jumps" by Pavel V. Gapeev, September 2006.
- 069 "Constrained General Regression in Pseudo-Sobolev Spaces with Application to Option Pricing" by Zdeněk Hlávka and Michal Pešta, September 2006.

**SFB 649, Spandauer Straße 1, D-10178 Berlin**  
<http://sfb649.wiwi.hu-berlin.de>

This research was supported by the Deutsche  
 Forschungsgemeinschaft through the SFB 649 "Economic Risk".



- 070 "The Welfare Enhancing Effects of a Selfish Government in the Presence of Uninsurable, Idiosyncratic Risk" by R. Anton Braun and Harald Uhlig, September 2006.
- 071 "Color Harmonization in Car Manufacturing Process" by Anton Andriyashin, Michal Benko, Wolfgang Härdle, Roman Timofeev and Uwe Ziegenhagen, October 2006.
- 072 "Optimal Interest Rate Stabilization in a Basic Sticky-Price Model" by Matthias Paustian and Christian Stoltenberg, October 2006.
- 073 "Real Balance Effects, Timing and Equilibrium Determination" by Christian Stoltenberg, October 2006.
- 074 "Multiple Disorder Problems for Wiener and Compound Poisson Processes With Exponential Jumps" by Pavel V. Gapeev, October 2006.
- 075 "Inhomogeneous Dependency Modelling with Time Varying Copulae" by Enzo Giacomini, Wolfgang K. Härdle, Ekaterina Ignatieva and Vladimir Spokoiny, November 2006.
- 076 "Convenience Yields for CO<sub>2</sub> Emission Allowance Futures Contracts" by Szymon Borak, Wolfgang Härdle, Stefan Trück and Rafal Weron, November 2006.
- 077 "Estimation of Default Probabilities with Support Vector Machines" by Shiyi Chen, Wolfgang Härdle and Rouslan Moro, November 2006.
- 078 "GHICA - Risk Analysis with GH Distributions and Independent Components" by Ying Chen, Wolfgang Härdle and Vladimir Spokoiny, November 2006.
- 079 "Do Individuals Recognize Cascade Behavior of Others? - An Experimental Study -" by Tim Grebe, Julia Schmid and Andreas Stiehler, November 2006.
- 080 "The Uniqueness of Extremum Estimation" by Volker Krätschmer, December 2006.
- 081 "Compactness in Spaces of Inner Regular Measures and a General Portmanteau Lemma" by Volker Krätschmer, December 2006.
- 082 "Probleme der Validierung mit Strukturgleichungsmodellen" by Lutz Hildebrandt and Dirk Temme, December 2006.
- 083 "Formative Measurement Models in Covariance Structure Analysis: Specification and Identification" by Dirk Temme and Lutz Hildebrandt, December 2006.

**SFB 649, Spandauer Straße 1, D-10178 Berlin**  
<http://sfb649.wiwi.hu-berlin.de>

This research was supported by the Deutsche  
Forschungsgemeinschaft through the SFB 649 "Economic Risk".

